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Itou et al.

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(54) **KEYBOARD MUSICAL INSTRUMENT EQUIPPED WITH PARTIALLY REPAIREABLE CHANGE-OVER MECHANISM FOR CHANGING HAMMER STOPPER**

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(52) **U.S. Cl.** **84/719**; 84/171; 84/220; 84/236

(58) **Field of Search** 84/2, 3, 171, 174, 84/216, 219–222, 236, 239, 719

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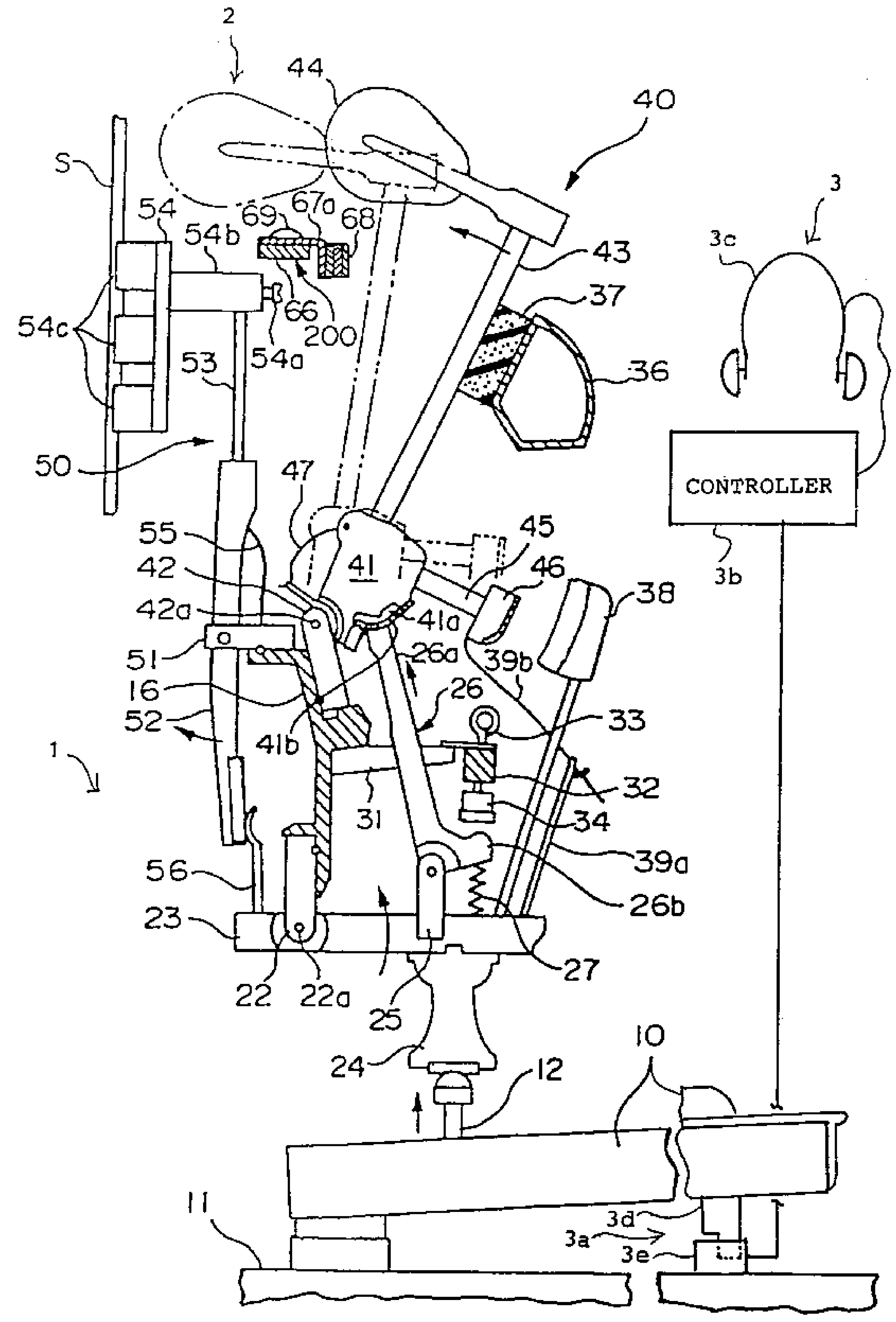
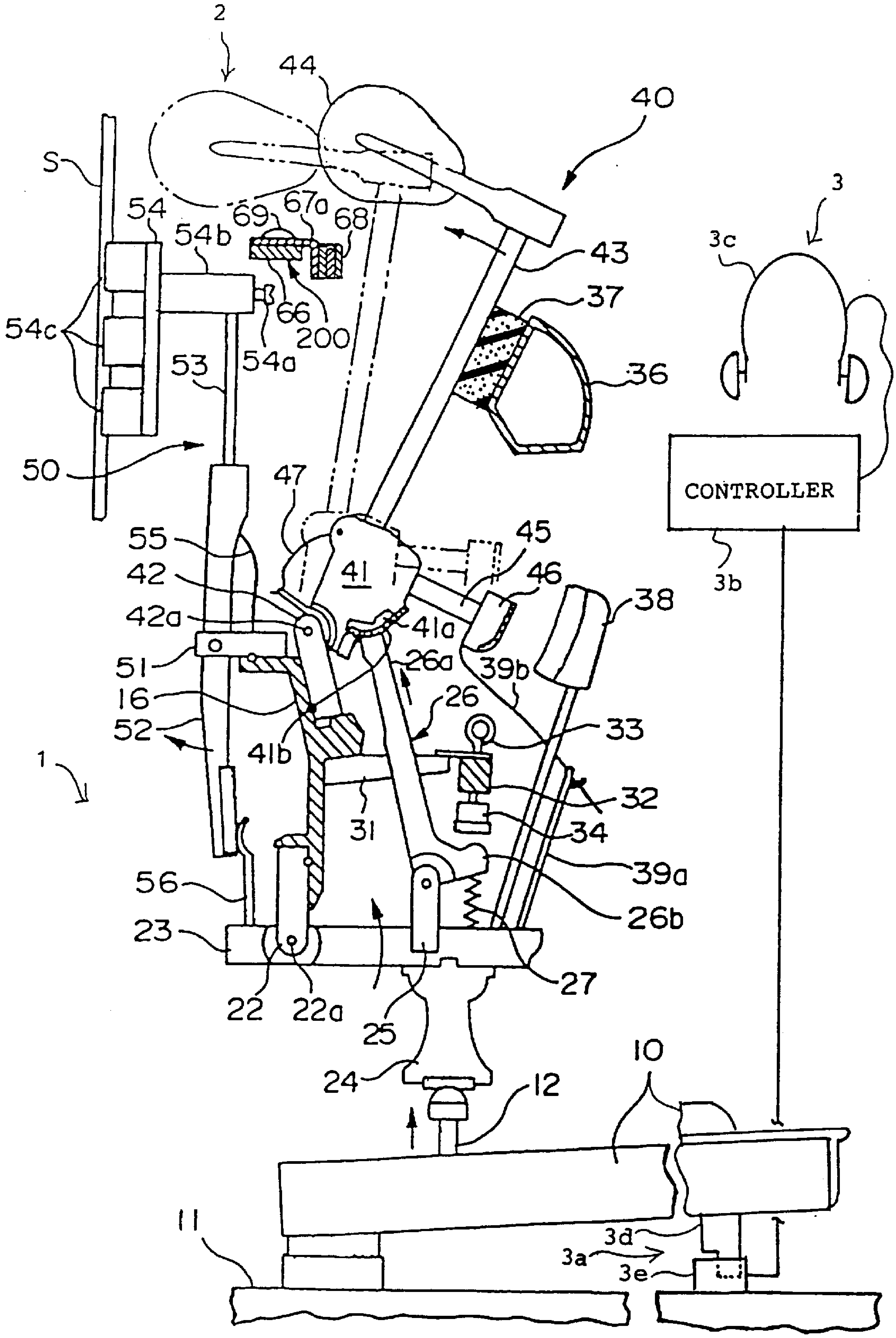
(74) *Attorney, Agent, or Firm*—Morrison & Foerster

(57) **ABSTRACT**

An acoustic piano is equipped with a shank stopper moved into and out of trajectories of hammer assemblies and a change-over mechanism for changing the shank stopper, and the change-over mechanism has a pedal, a transmitter connected to the pedal and another transmitter held in contact with the transmitter for transmitting force exerted on the pedal to the shank stopper, wherein the transmitters are only restricted in the direction to transmit the force from the pedal to the shank stopper so that the transmitters are independently disassembled and regulable.

13 Claims, 11 Drawing Sheets





2
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40
S
54
69
67a
68
54b
43
37
54c
66
200
54a
53
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3c
50
CONTROLLER
3b
47
55
45
42
46
38
42a
41
41a
51
26a
39b
16
26
52
33
41b
32
31
34
56
39a
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22a
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12
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3d
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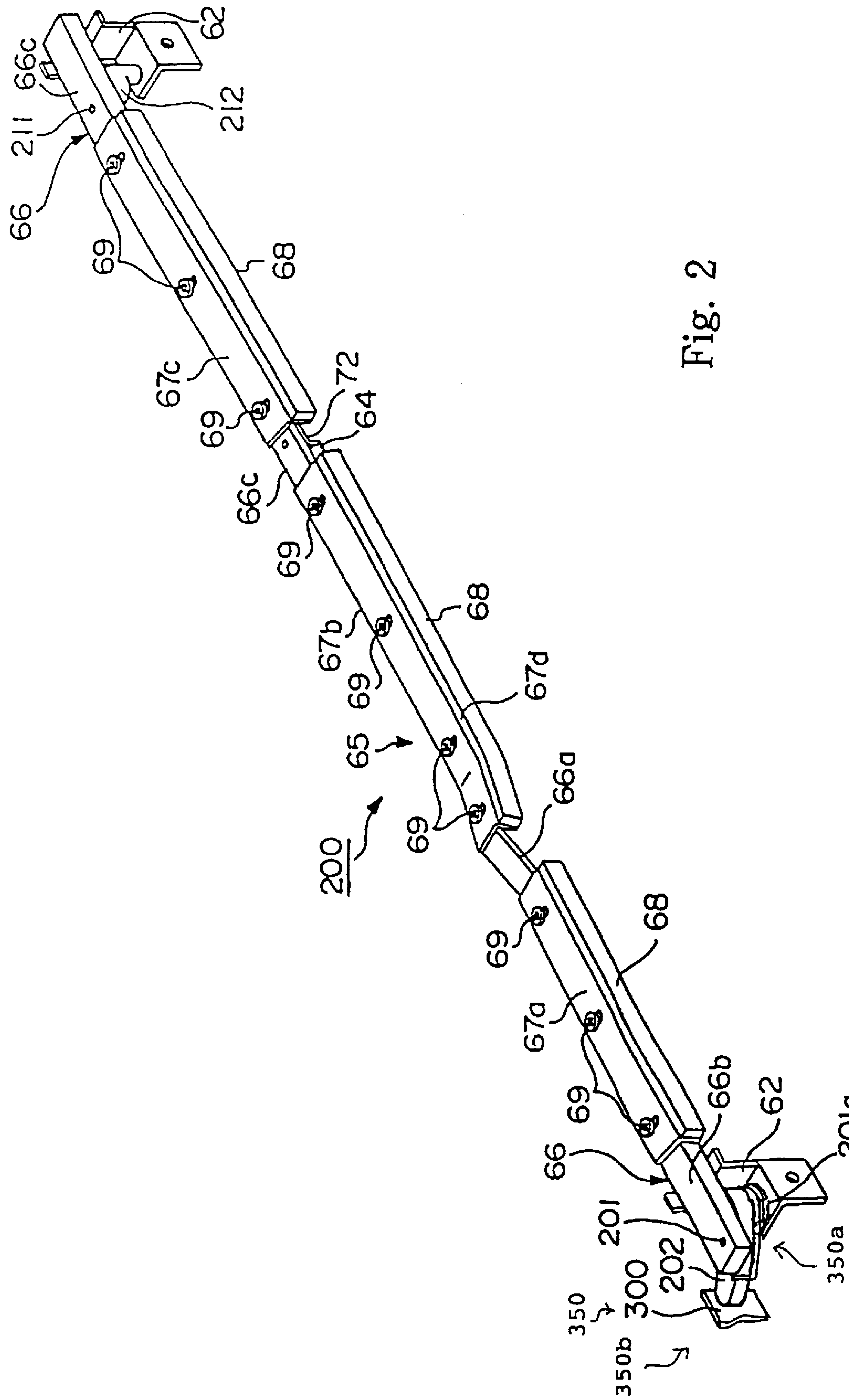
3e
1

Fig. 1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67a
66b
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201a
66
201
202
300
350
350a
350b

Fig. 2

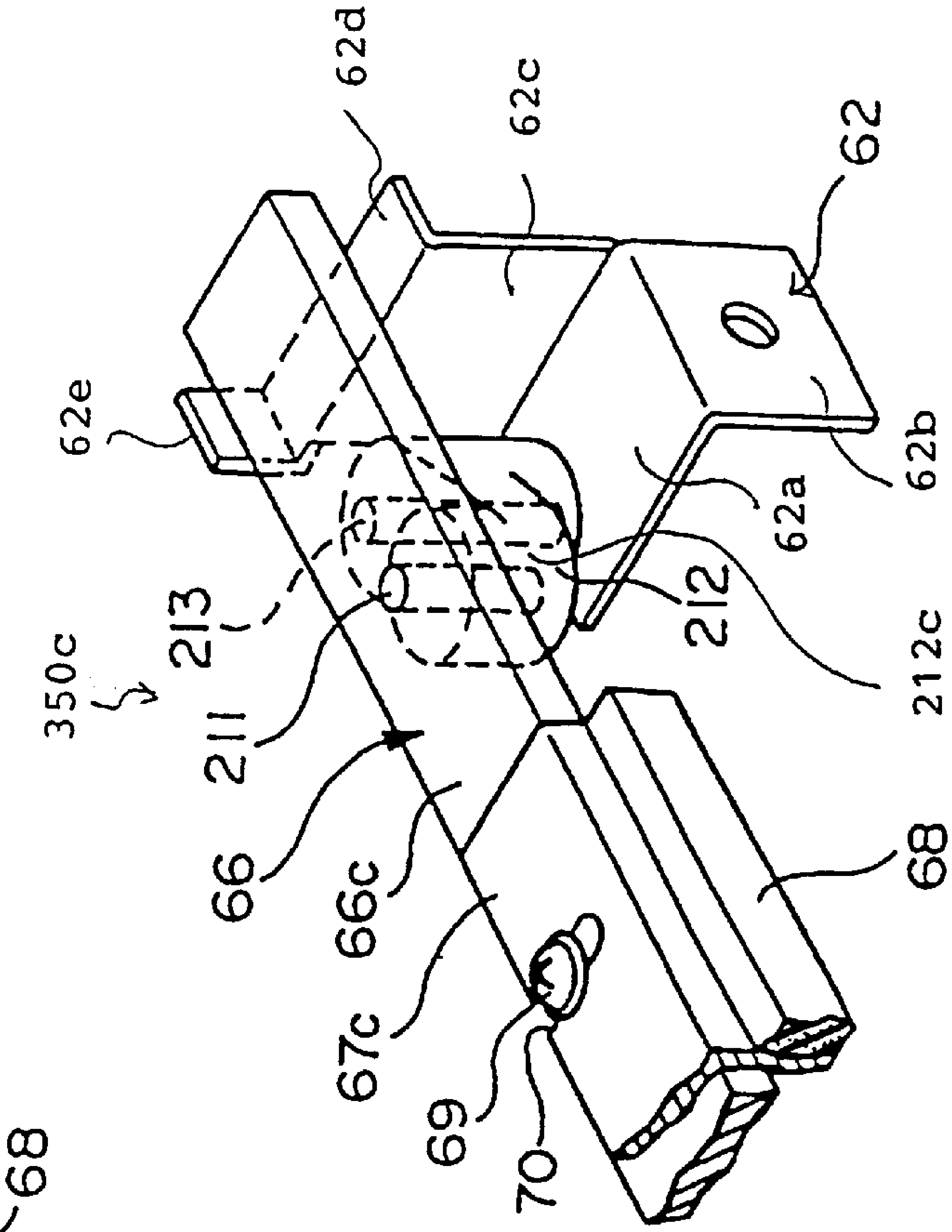
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Fig. 3B

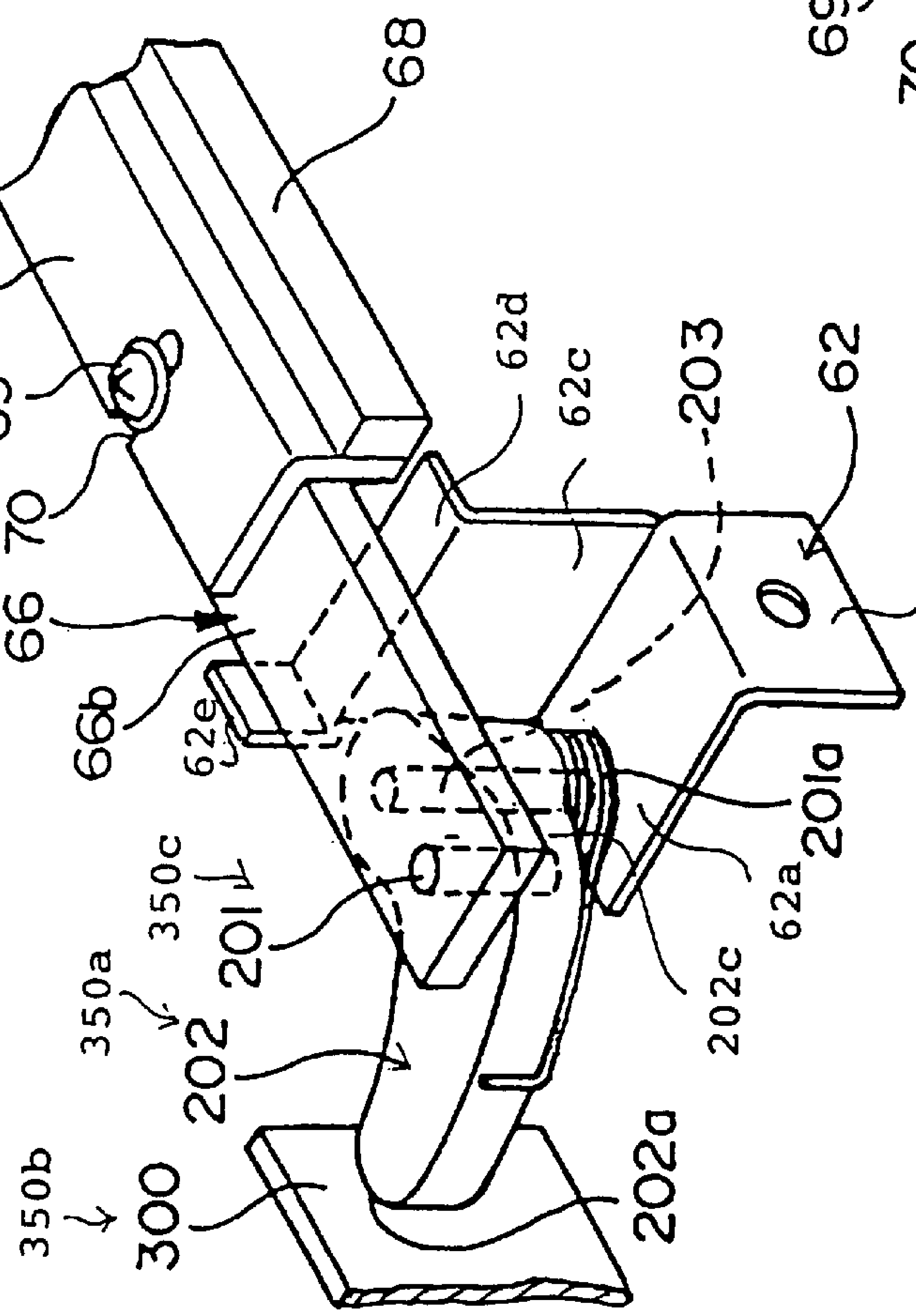
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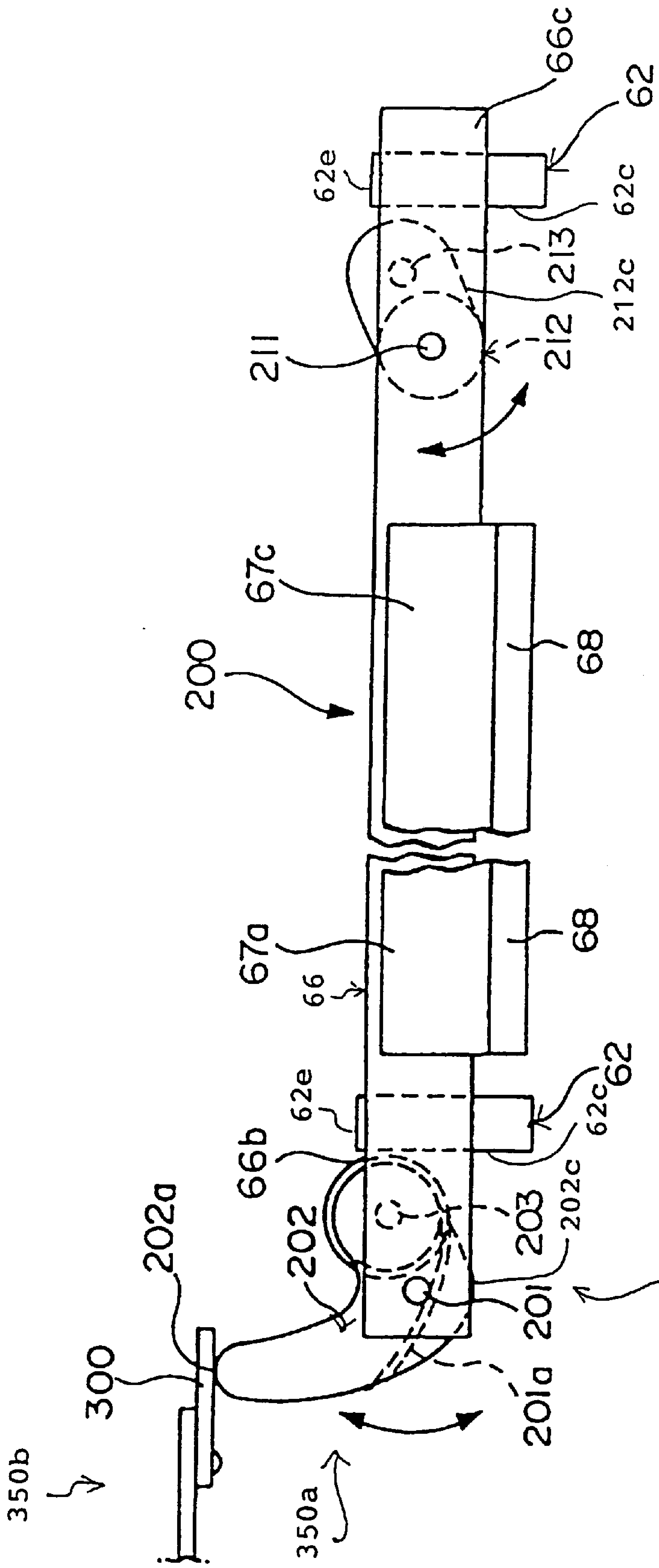
Fig. 3A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350b
350a

Fig. 4A

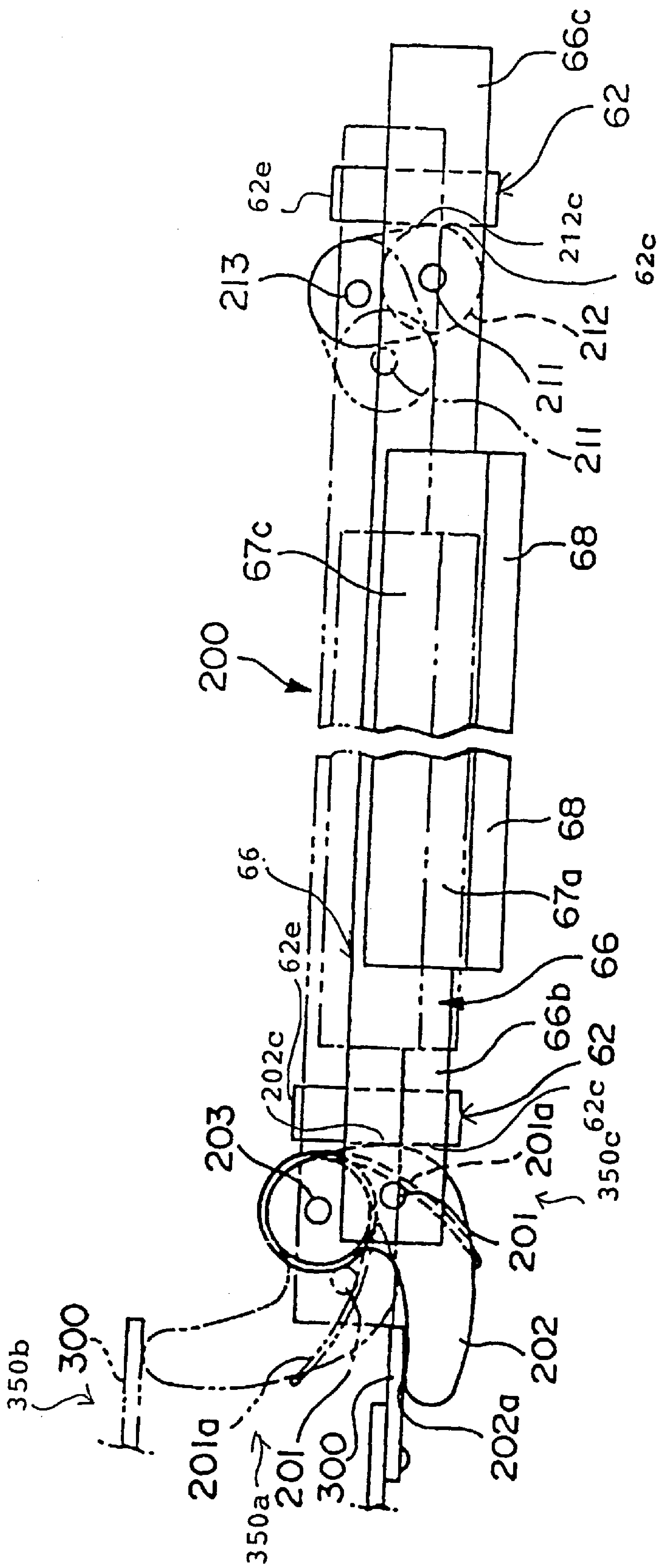
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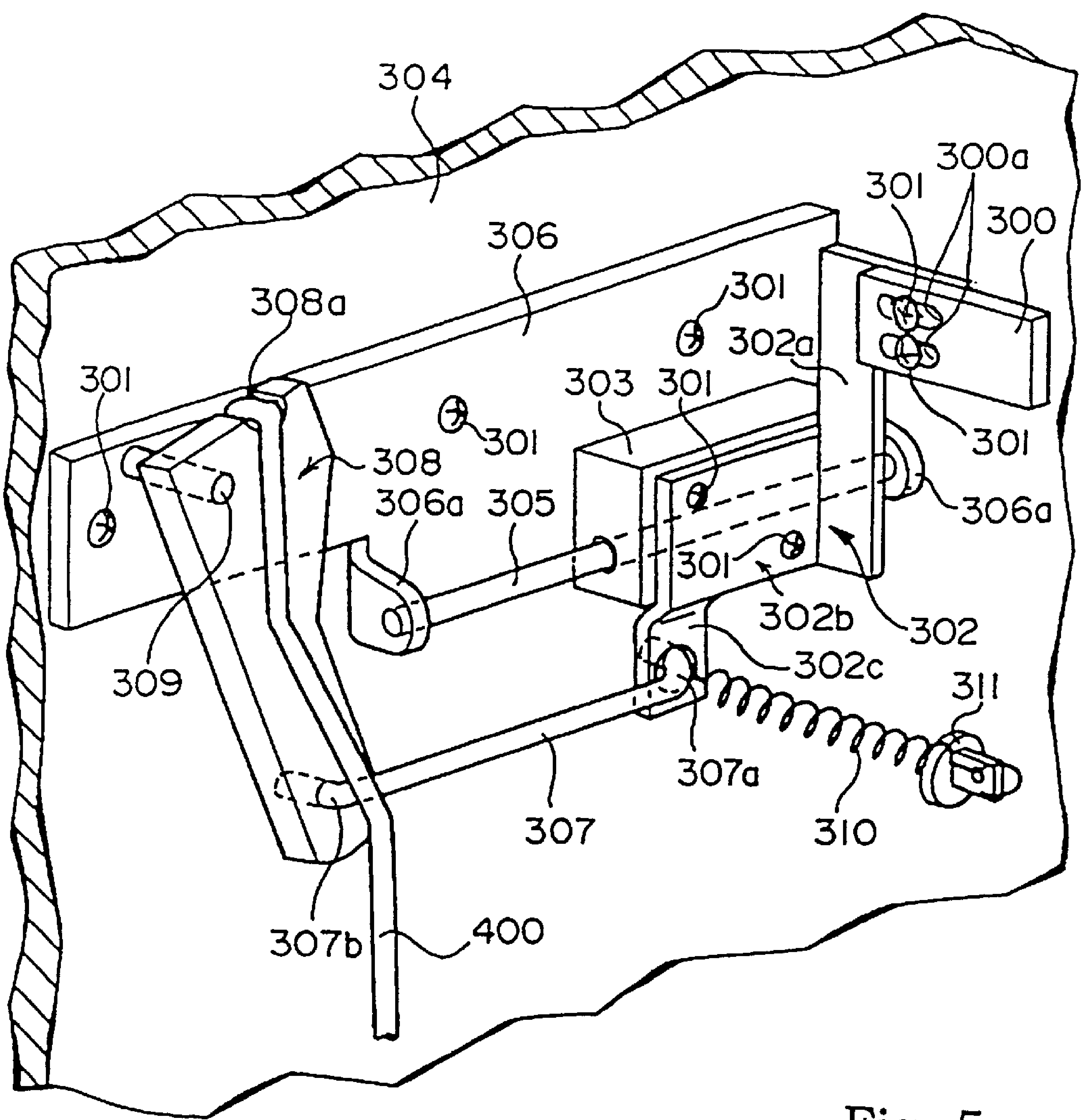
Fig. 4B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307a
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310
307b
400

Fig. 5

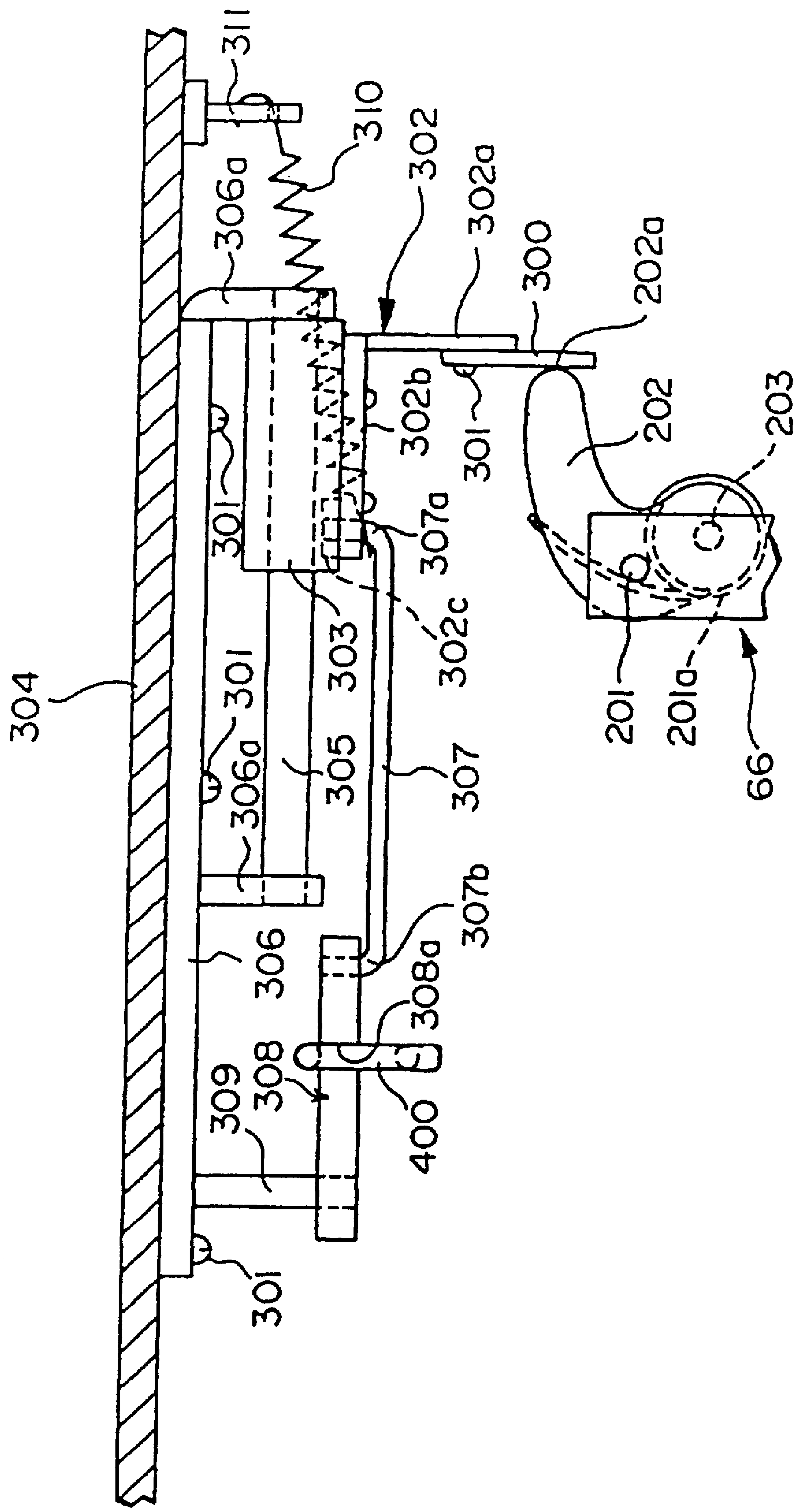
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Fig. 6

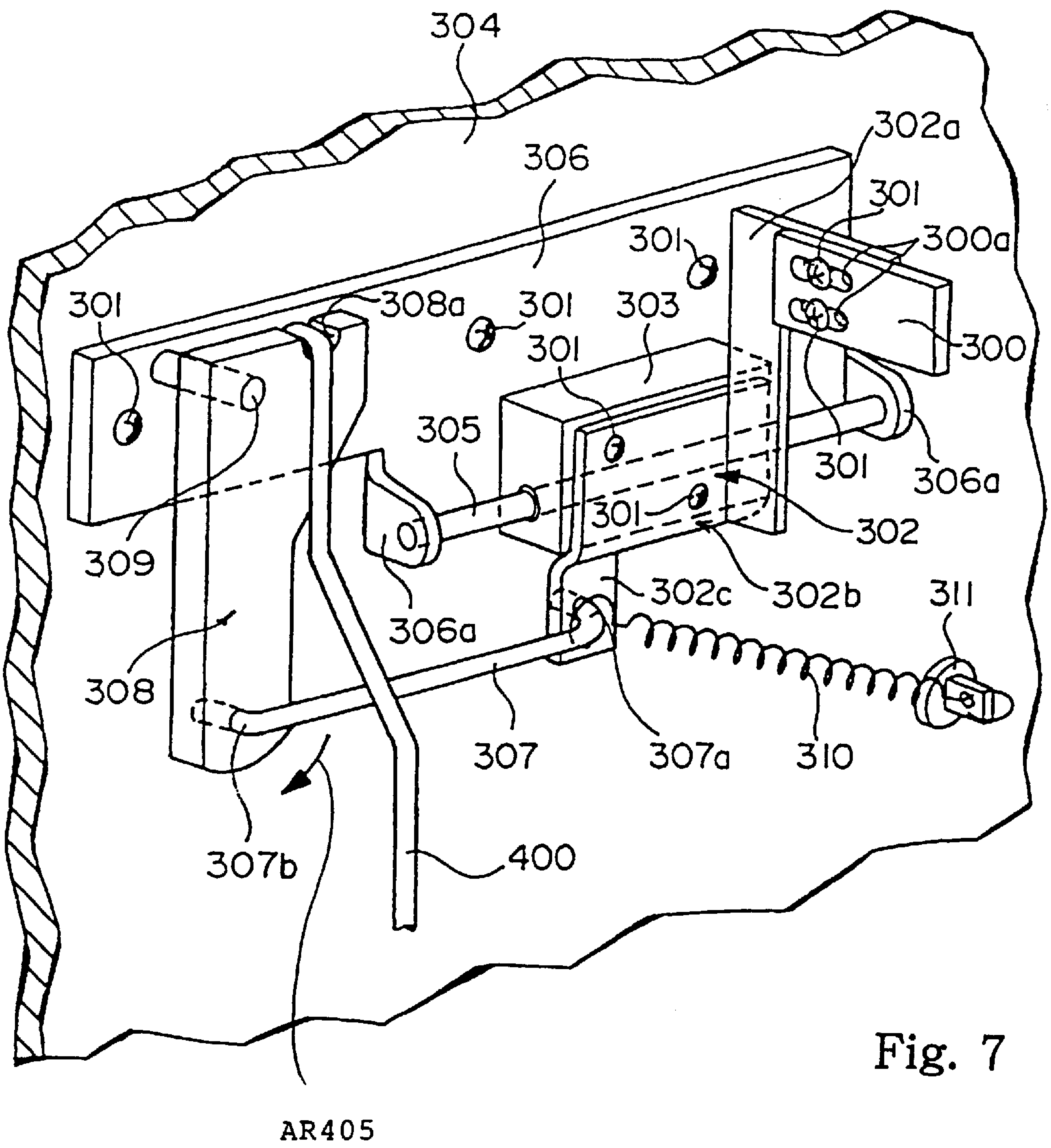
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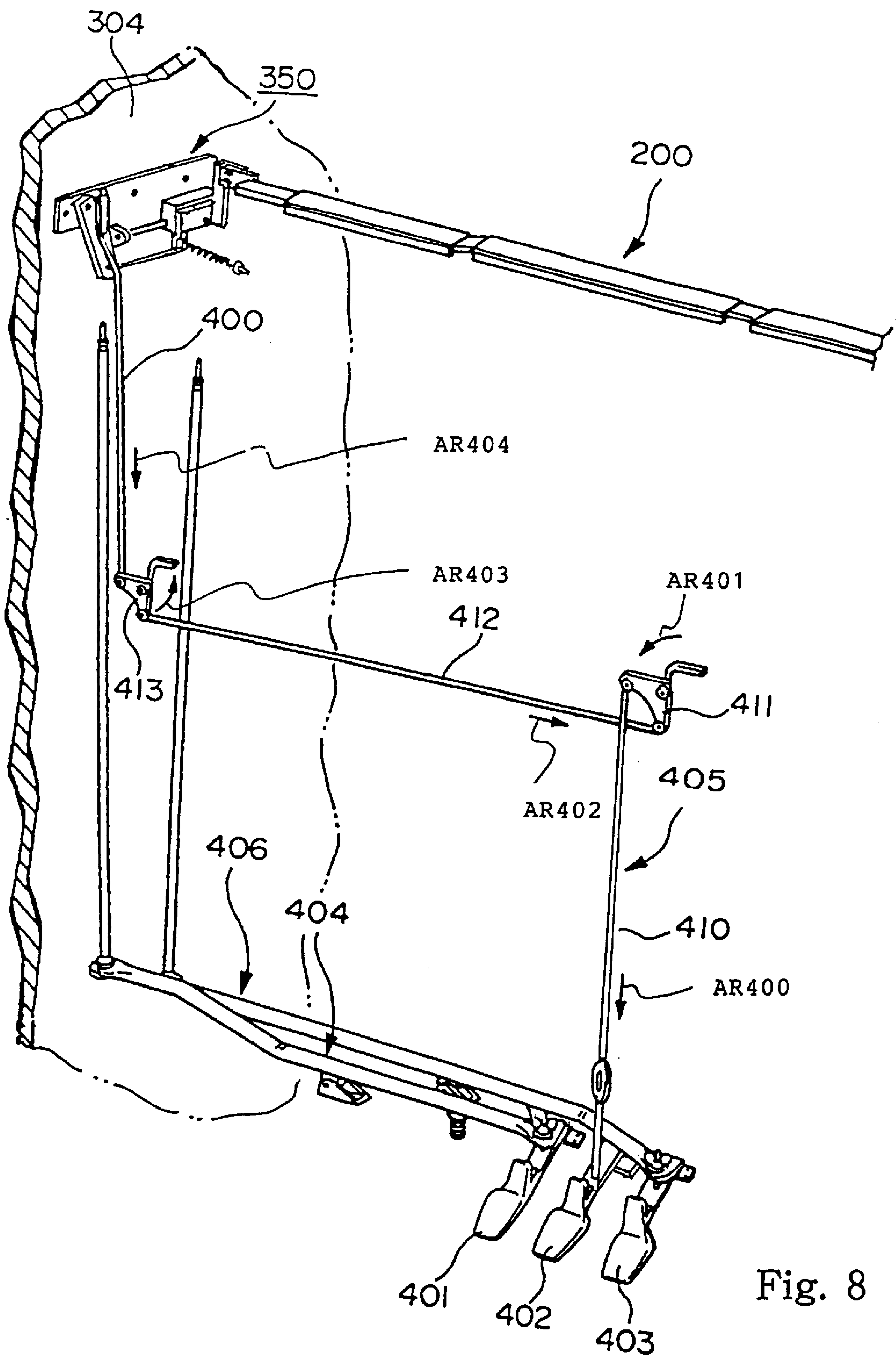
Fig. 7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AR400
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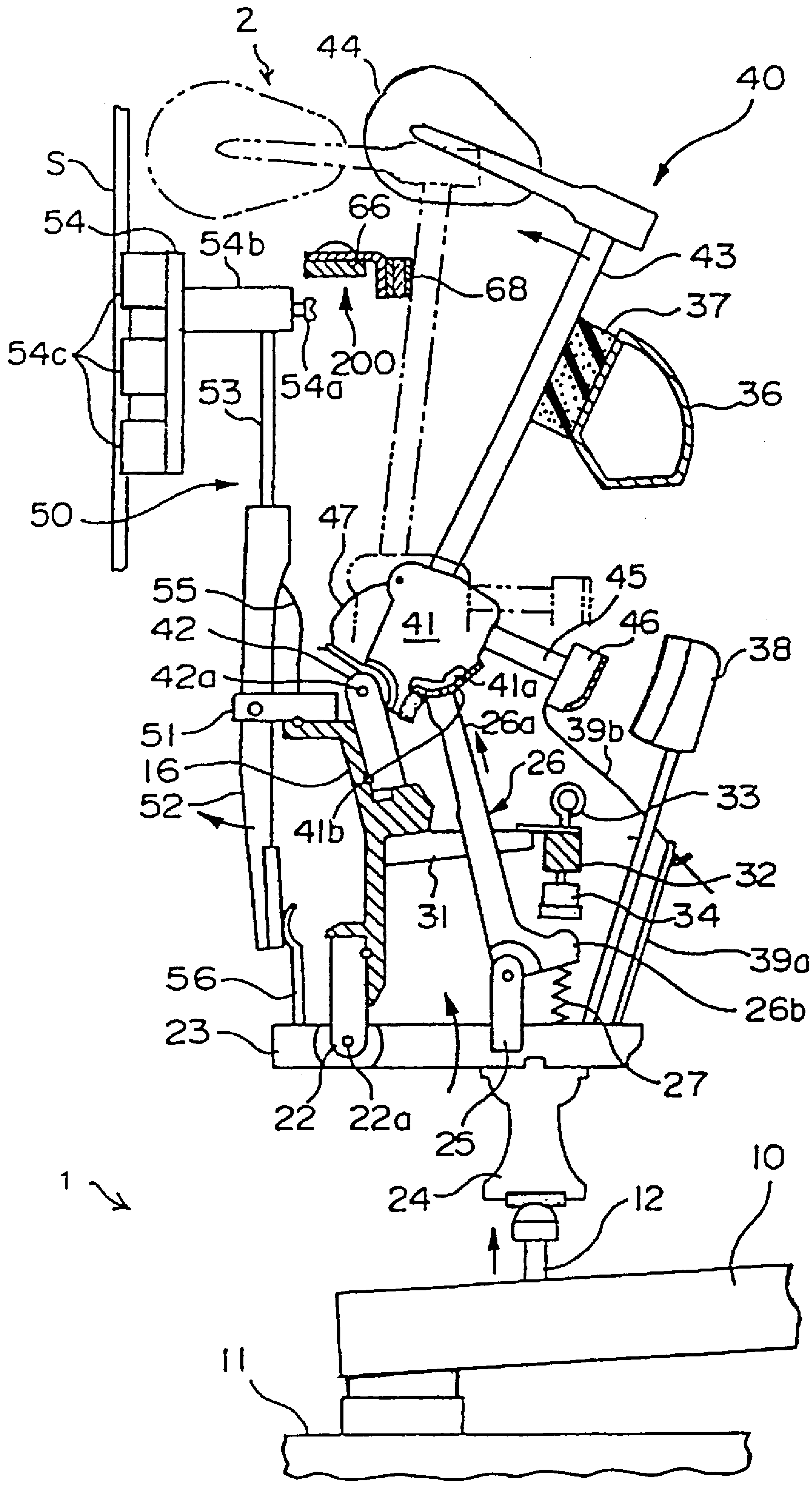
403

Fig. 8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26a
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39b
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33
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22a
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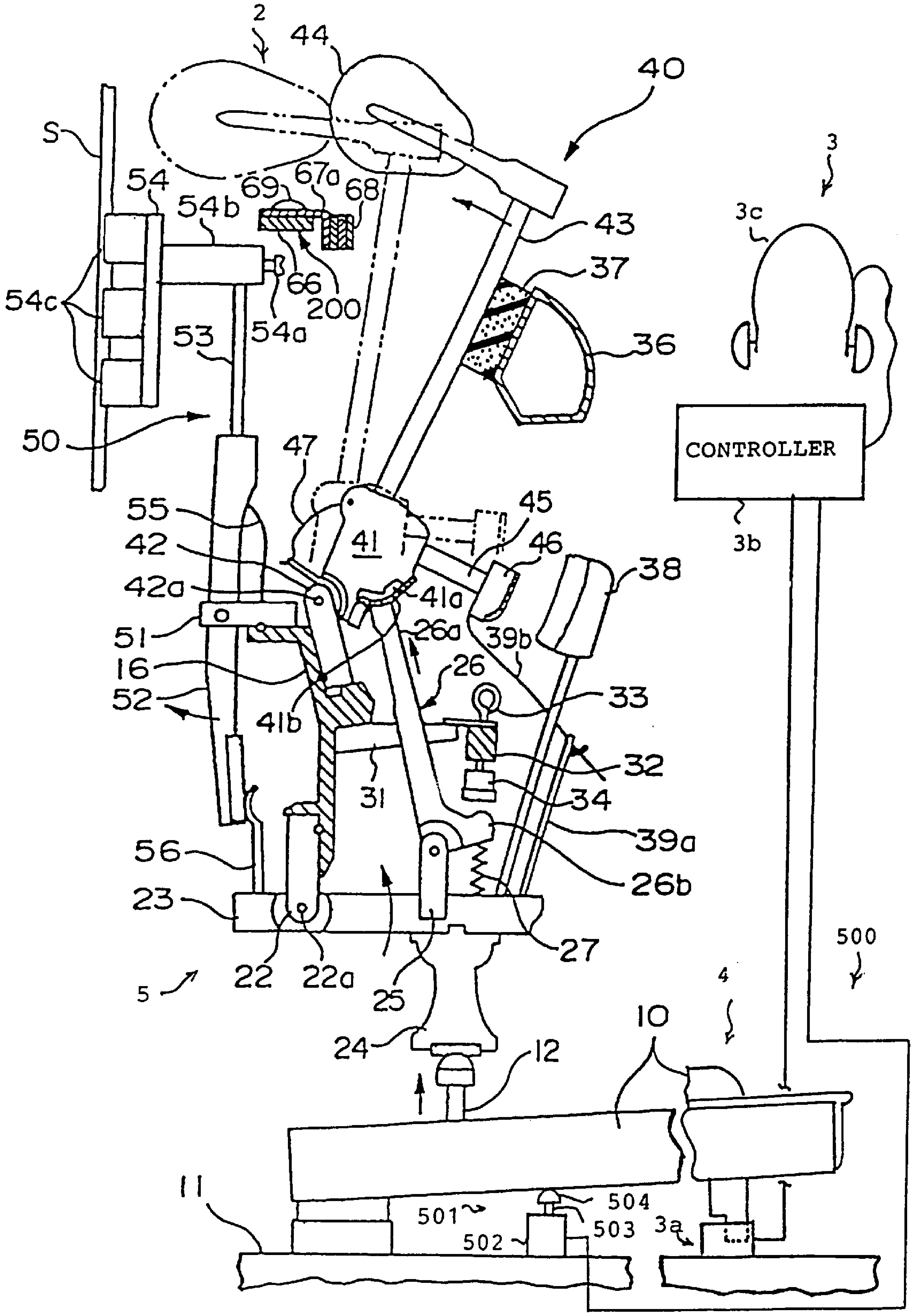
Fig. 9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42a
41a
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26a
39b
16
26
52
41b
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32
31
34
39a
56
26b
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27
22
22a
25
5
24
12
500
4
10
11
501
504
503
3a
502

Fig. 10

KEYBOARD MUSICAL INSTRUMENT EQUIPPED WITH PARTIALLY REPAIREABLE CHANGE-OVER MECHANISM FOR CHANGING HAMMER STOPPER

FIELD OF THE INVENTION

This invention relates to a keyboard musical instrument and, more particularly, to a keyboard musical instrument with a silent system for playing a passage on a keyboard without acoustic tones.

DESCRIPTION OF THE RELATED ART

The keyboard musical instrument is fabricated on the basis of an acoustic piano, and equipped with a silent system and an electronic sound system. The silent system has a hammer stopper changed between a free position and a blocking position. While a pianist is playing a tune on the keyboard, the hammers rebound on the hammer stopper in the blocking position before striking the music strings, and the music strings do not vibrate. The electronic sound system detects the key motions, and generates electronic sounds instead of the acoustic tones. When the silent system is changed to the free position, the hammer stopper is moved out of the trajectories of the hammers, and the hammers are allowed to selectively strike the associated music strings for generating the acoustic tones.

A shank stopper is a kind of the hammer stopper, and is popular with the actual products. The shank stopper laterally extends between the music strings and the hammer shanks, and, accordingly, is shared between the hammers. While a hammer is being driven for rotation toward the associated music string, the hammer shank is brought into contact with the shank stopper, and rebounds thereon. The shank stopper is, by way of example, connected through a wire to a grip or a pedal. A suitable converting member may be connected between the wire and the shank stopper so as to convert reciprocal motion of the wire to rotation of the shank stopper between the free position and the blocking position.

A problem is encountered in the prior art silent system in that workmen feel the installation inside the acoustic piano and the maintenance work time-consuming. This is because of the fact that the plural independent parts are assembled into the prior art hammer stopper. While workmen are assembling the plural independent parts such as the shank stopper, the converting member, the wire and the pedal/grip into the prior art hammer stopper inside the acoustic piano, the workmen connect the independent parts to one another in a predetermined sequence, and regulate the play and gap between the parts. When a workman replaces one of the parts to new one, the workman disassembles the prior art hammer stopper, replaces the part with new one, assembles them into the prior art hammer stopper, again, and regulates the play and gap between the parts. Thus, the installation and the maintenance work are time-consuming.

SUMMARY OF THE INVENTION

It is therefore an important object of the present invention to provide a keyboard musical instrument with a silent system, which is easily installed and maintenance work is simple.

To accomplish the object, the present invention proposes to restrict a contact between a first transmitter and a second transmitter in a direction to transmit a force.

In accordance with one aspect of the present invention, there is provided a keyboard musical instrument comprising an acoustic keyboard including plural keys selectively depressed by a player, plural music strings respectively associated with the plural keys and plural strikers driven by depressing the plural keys for striking the associated music strings and a silent system including a stopper moved between a free position and a blocking position so that the plural strikers strike the plural music strings without any interruption thereof at the free position and rebound thereon at the blocking position before striking the plural music strings and a change-over mechanism having a first transmitter connected to the stopper for changing the stopper between the free position and the blocking position and a second transmitter held in contact with the first transmitter without any restriction in a first direction for transmitting a force to the first transmitter in a second direction different from the first direction.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and advantages of the keyboard musical instrument will be more clearly understood from the following description taken in conjunction with the accompanying drawings in which:

FIG. **1** is a side view showing an essential part of a keyboard musical instrument according to the present invention;

FIG. **2** is a perspective view showing a shank stopper incorporated in a silent system of the keyboard musical instrument;

FIGS. **3**A and **3**B are perspective views showing a change-over mechanism incorporated in the silent system;

FIGS. **4**A and **4**B are plane views showing the shank stopper in a free position and a blocking position, respectively;

FIG. **5** is a perspective view showing the change-over mechanism in the free position;

FIG. **6** is a plane view showing the change-over mechanism;

FIG. **7** is a perspective view showing the change-over mechanism in the blocking position;

FIG. **8** is a perspective view showing the silent system;

FIG. **9** is a side view showing the keyboard musical instrument in the silent mode; and

FIG. **10** is a side view showing essential parts of another keyboard musical instrument according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

First Embodiment

Referring to FIG. **1** of the drawings, a keyboard musical instrument embodying the present invention largely comprises an acoustic piano **1**, a silent system **2** and an electronic sound generating system **3**. Although an upright piano is used as the acoustic piano **1** in this instance, a grand piano is available for the keyboard musical instrument. In the following description, term "front" is used for a position closer to a pianist who is playing a passage on the acoustic piano than a "rear" position. A direction between a front position and a corresponding rear position is referred to as "fore-and-aft direction", and a lateral direction is perpendicular to the fore-and-aft direction.

The acoustic piano **1** comprises keyboard **4** and action mechanisms **5** linked with the keyboard **4**. Black keys **10** and white keys **10** form the keyboard **4**, and are laid on the well-known pattern. The keyboard **4** is mounted on a key bed **11**, which forms a part of a piano case. Capstan screws **12** project from the rear end portions of the black/white keys **10**. The action mechanisms **5** are associated with the black/white keys **10**, respectively, and are actuated by the associated black/white keys **10**.

A center rail **16** laterally extends over the rear end portions of the black/white keys **10**, and are supported by means of action brackets (not shown) on the key bend **11**. The action mechanisms **5** are connected to the center rail **16** at intervals. The action mechanisms **5** are similar in structure to one another, and the structure of the action mechanism **5** is described hereinlater in detail.

The action mechanism **5** includes a whippen flange **22**, a whippen **22** and a whippen heel **24**. The whippen flange **22** is bolted to the center rail **16**, and the whippen **23** is rotatably connected to the lower end portion of the whippen flange by means of a center pin **22***a*. The center pin **22***a* is closer to the rear end surface of the whippen than the front end surface thereof. The whippen heel **24** is attached to the lower surface of the whippen **23**, and is farther from the rear end surface than the center pin **22***a*. The capstan screw **12** is held in contact with the whippen heel **24** as shown. When a pianist depresses the front end portion of the associated black/white key **10**, the capstan screw **12** upwardly pushes the whippen heel **24**, and gives rise to rotation of the whippen **23** in the counter clockwise direction around the whippen flange **22**.

The action mechanism **5** further includes a jack flange **25**, a jack **26** and a jack string **27**. The jack flange **25** is upright from the whippen **23**, and is farther from the rear end surface than the center pin **22***a*. The jack is rotatably supported by the jack flange **25**, and the jack spring **27** urges the jack **26** in the counter clockwise direction at all times. The jack **26** is shaped in an L-letter configuration, and the long portion **26***a* and the short portion **26***b* are referred to as "leg" and "tow", respectively.

The action mechanism **5** further includes fork screws **31**, a regulating rail **32**, a regulating screw **33** and a regulating button **34**. The fork screws **31** project from the center rail **16**, and the regulating rail **32** is connected to the front end portions of the fork screws **31**. Thus, the regulating rail **32** laterally extends over the tows **26***b* of the jacks **26**. The regulating button **34** is connected through the regulating screw **33** to the regulating button **34**, and the tow **26***b* is opposed to the lower surface of the regulating button **34**. The gap between the tow **26***b* and the regulating button **34** is regulable by twisting the regulating screw **33**.

While the player is depressing the black/white key **10**, the whippen **23** is rotated around the whippen flange **22** in the counter clockwise direction, and the jack **26** is also rotated around the whippen flange **22** without relative rotation around the jack flange **25**. The tow **26***b* is getting closer and closer to the regulating button **34**, and is brought into contact with the regulating button **34**. Then, the jack **26** turns around the jack flange **25** in the clockwise direction against the elastic force of the jack string **27**, and escapes.

A hammer rail **36** laterally extends over the regulating rail **32**, and a hammer rail cloth **37** is attached to the rear surface of the regulating rail **32**. The action mechanism **5** further includes a back check **38**, a bridle wire **39***a* and a bridle tape **39***b*. The back check **38** is maintained over the front end portion of the whippen **23**, and the bridle wire **39***a* upwardly projects from the front end portion of the whippen **23**. The back check **38** and the bridle tape **39***b* will be hereinbelow described.

The acoustic piano **1** further comprises hammer assemblies **40** and damper mechanisms **50** and sets of strings S. The hammer assemblies **40** are associated with the action mechanisms **5**, respectively, and are driven for rotation by the jacks **26** of the associated action mechanisms **5** at the escape. The damper mechanisms **50** are also associated with the action mechanisms **5**, and absorb the vibrations of the associated sets of strings S. When the associated black/white keys **10** are staying in the rest positions, the damper mechanisms **50** do not allow the associated sets of strings S to vibrate, and any acoustic tone is not generated from the sets of strings S. The damper mechanism **50** allows the associated set of strings S at a certain key position on the way toward the end position. When the associated black/white key **10** passes the certain key position, the jack **26** is rotated around the whippen flange **22** without the relative rotation around the jack flange **25**, and has not escaped from the hammer assembly **40**, yet. In other words, the jack **26** escapes from the associated hammer assembly **40** after the damper mechanism **50** has allowed the set of strings S to vibrate. For this reason, when the hammer assembly **40** strikes the set of strings S, the strings S vibrate so as to generate the acoustic tone. When the pianist releases the depressed black/white key **10**, the whippen **23** is rotated around the whippen flange **22** in the clockwise direction, and the damper mechanism **50** prohibits the associated set of strings S from the vibrations.

The hammer assemblies **40** are similar in structure to one another, and the structure is described hereinbelow in detail. The hammer assembly **40** includes a hammer butt **41**, a butt flange **42**, a hammer shank **43** and a hammer head **44**. The butt flange **42** is fixed to the front surface of the center rail **16**, and the hammer butt **41** is rotatably connected to the butt flange **42** by means of a center pin **42***a*. The hammer shank **43** upwardly projects from the hammer butt **41**, and the hammer head **44** is attached to the leading end of the hammer shank **43**. The hammer head **44** is directed to the associated set of strings S.

The hammer assembly **40** further comprises a catcher shank **45**, a catcher **46** and a butt spring **47**. The catcher shank **45** projects from the hammer butt **41** in the perpendicular direction to the hammer shank **43**, and the catcher **46** is attached to the leading end of the catcher shank **46**. The butt spring **47** is inserted between the butt flange **42** and the hammer butt **41**, and urges the hammer assembly **40** to turn in the clockwise direction. For this reason, while the associated black/white key **10** is staying in the rest position, the hammer shank **43** is held in contact with the hammer rail cloth **37** due to the elastic force of the butt spring **47**. The catcher **45** is connected through the bridle tape **39***b* to the bridle wire **39***a*, and the hammer assembly **40** is linked with the whippen **23** by means of the bridle tape **39***b* and the bridle wire **39***a*. When the hammer assemblies **40** rebound on the sets of strings S, the hammer assemblies **40** start the rotation in the clockwise direction. The catcher **46** is brought into contact with the back check **38**. However, the hammer assemblies **40** do not strike the sets of strings S, again, because the bridle tapes **39***b* set a limit on the rebound.

A butt under felt **41***a* is attached to a lower surface of the hammer butt **41**, and a butt skin **41***b* is laminated on the butt under felt **41***a*. The leading end surface of the leg **26***a* is held in contact with the butt skin **41***b* until the escape from the hammer butt **41**. While a pianist is depressing the associated black/white key **10**, the jack **26** turns around the whippen flange **22** in the counter clockwise direction, and pushes the butt skin **41***b*. As a result, the jack **26** gives rise to rotation of the hammer assembly **40** in the counter clockwise direction around the butt flange **42** until the escape. When the jack **26** escapes from the hammer butt **41**, the hammer assembly **40** starts the free rotation toward the associated set of strings S.

The damper mechanisms **50** are similar in structure to one another. Each of the damper mechanisms **50** includes a damper flange **51**, a damper lever **52**, a damper wire **53**, a damper head **54**, a damper spring **55** and a damper spoon **56**. The damper flange **51** is fixed to the center rail **16**, and the damper lever **52** is rotatably connected to the damper flange **51** at an intermediate position thereof. The damper wire **53** upwardly projects from the damper lever **52**, and the damper head **54** is attached to the leading end of the damper wire **53**.

A damper screw **54***a* fixes a damper wood **54***b* to the damper wire **53**, and damper felts **54***c* are attached to the rear surface of the damper wood **54***b*. The damper spring **55** urges the damper lever **52** in the counter clockwise direction at all times. The damper spoon **56** upwardly projects from the rear end portion of the whippen **23**, and is held in contact with the damper lever **52**. While the associated black/white key **10** is staying in the rest position, the whippen **23** is substantially horizontal, and the damper spoon **56** allows the damper spring **55** to hold the damper felts **54***c* into contact with the associated set of strings S. When a pianist depresses the black/white key **10**, the whippen **23** is rotated in the counter clockwise direction, and the damper spoon **56** backwardly inclines. The damper spoon **56** pushes the damper lever **52**, and gives rise to rotation in the clockwise direction around the damper flange **51**. As a result, the damper felts **54***c* are spaced from the associated set of strings S. When the pianist releases the depressed black/white key **10**, the whippen **23** is recovered to the horizontal position, and the damper spring **55** brings the damper felts **54***c* into contact with the associated set of springs S, again. While the damper felts **54***c* are being spaced from the associated set of strings S, the hammer assembly **40** strikes the sets of strings S, and the sets of strings S generate an acoustic tone through the vibrations. However, when the damper felts **54***c* are brought into contact with the set of strings S, the damper felts **54***c* absorb the vibrations, and the acoustic tone is decayed.

The silent system **2** includes a shank stopper **200** and a change-over mechanism **350** (see FIGS. **2** to **8**). The shank stopper **200** is provided between the hammer shanks **43** and the sets of strings S, and a pianist changes the silent system **200** between the free position and the blocking position by means of the change-over mechanism **350**. When the pianist changes the silent system **2** to the blocking position, the shank stopper **200** is frontwardly moved, and is positioned on the trajectories of the hammer shanks **43**. When the pianist changes the silent system **2** to the free position, the shank stopper **200** is backwardly moved, and is positioned out of the trajectories of the hammer shanks **43**. Thus, the shank stopper **200** is bi-directionally moved in the fore-and-aft direction.

The shank stopper **200** is illustrated in FIG. **2** in detail. The shank stopper **200** includes a rail base **66**, stopper rail segments **67***a*/**67***b*/**67***c* and impact absorbers **68**. The rail base **66** is as long as the array of the hammer assemblies **40**, and has a sloop **66***a* between a short portion **66***b* and a long portion **66***c*. The long portion **66***c* is partially raised, and is connected through the sloop **66***a* to the short portion **66***b*. The stopper rail segments **67***a*/**67***b*/**67***c* are assigned to the lower pitched part, the middle pitched part and the higher pitched part, respectively, and the impact absorbers **68** are attached to the front surfaces of the stopper rail segments **67***a*/**67***b*/**67***c*.

The stopper rail segment **67***a* is fixed to the short portion **66***b* by means of bolts **69**, and the other stopper rail segments **67***b*/**67***c* are bolted to the long portion **66***c* by means of bolts **69**. As will be better seen in FIGS. **3**A and **3**B, the stopper rail segments **67***a*/**67***b*/**67***c* have an L-letter shape, and slots **70** are formed in the stopper rail segments **67***a*/**67***b*/**67***c*. The slots **70** are open at the rear surfaces of the stopper rail segments **67***a*/**67***b*/**67***c*, and are elongated in the fore-and-aft direction. The bolts **68** pass the slots **70**, and are screwed into threaded holes formed in the rail base **66**. This means that the stopper rail segments **67***a*/**67***b*/**67***c* are independently regulable with respect to the rail base **66**. In detail, an operator loosens the bolts **69**, and makes the stopper rail segments **67***a*/**67***b*/**67***c* slidable on the rail base **66**. When the stopper rail segments **67***a*/**67***b*/**67***c* are adjusted to appropriate positions, respectively, the operator screws the bolts **69** into the stopper rail segments **67***a*/**67***b*/**67***c*, and the bolts **69** press the stopper rail segments **67***a*/**67***b*/**67***c* against the rail base **66**. Thus, each of the stopper rail segments **67***a*/**67***b*/**67***c* and, accordingly, the impact absorber **68** are adjusted to a position appropriate to the hammer assemblies **40** assigned to one of the pitched parts independently of the other stopper rail segments and the impact absorbers **68** attached thereto. The appropriate position of each impact absorber **68** is between a position of the hammer shank **43** at the escape and another position of the hammer shank **43** at the strike against the set of strings S. The distance between the two positions is short, and the pair of positions is not constant between the groups of the hammer assemblies **40** respectively assigned to the three pitched parts. If the impact absorbers **68** are regulated to appropriate thickness, the irregularity may be taken up. However, the shank stopper **200** requires three kinds of impact absorber **68** different in thickness, and the three kinds of impact absorbers **68** increase the number of the component parts. The stopper rail segments **67***a*/**67***b*/**67***c* require only one kind of impact absorbers **68**, and reduce the number of component parts of the silent system.

The impact absorbers **68** have a laminated structure, and a resilient layer is covered with a protective layer. The resilient layer may be formed of urethane foam or felt, and the protective layer may be formed of artificial leather. As described hereinbefore, the left part of the long portion **67***b* is upwardly bent, and is connected through the sloop **66***a* to the short portion **67***a*. The stopper rail segment **67***b* has a left part **67***d* bent from the remaining part, and, accordingly, the impact absorber **68** is partially bent toward the sloop **66***a*.

The sets of strings S are stretched over a frame (not shown), and are divided into two groups. The first group is assigned to the lower pitched part, and the second group is assigned to the middle/higher pitched parts. The first group obliquely extends from the upper end of the left side toward the lower end of the right side, and the second group extends from the upper end of the right side toward the lower end of the left side. Accordingly, the sets of strings S for the lower pitched group cross several sets of strings S for the middle pitched part. In order to dodge the sets of strings S for the higher pitched part, the hammer heads **44** and the damper heads **54***b* for the several sets of strings S are located to be higher than those for the other sets of the strings S in the same part. This is the reason why the rail base **66**, the stopper rail segment **67***b* and the impact absorber **68** are upwardly bent. The hammer shanks **43** for the several sets of strings S rebound on the oblique portion of the impact absorber **68** attached to the stopper rail segment **67***b* without undesirable interference between the impact absorber **68** and the damper mechanisms **50**.

The change-over mechanism **350** is broken down into two transmitters **350***a*/**350***b*, a contact keeper **201***a*, a limiter **350***c* and a muffler pedal **402**. The transmitter **350***a* is connected to the shank stopper **200**, and the other transmitter **350***b* is connected to the muffler pedal **402**. The transmitter

350*a* is held in contact with the other transmitter **350***b* by means of the contact keeper **201***a*. In this instance, the contact keeper is implemented by a torsion spring **201***a*. When a pianist steps on the muffler pedal **402**, the force is transmitted through the transmitters **350***a*/**350***b* to the shank stopper **200**, and the shank stopper **200** is changed between the free position and the blocking position. The limiter **50***c* sets a limit on the trajectory of the transmitter **350***a* and, accordingly, the shank stopper **200** so as to exactly position the shank stopper **200** at the blocking position and the free position.

The transmitter **350***a*, the contact keeper **201***a* and the limiter **350***c* are shown in FIGS. **3**A and **3**B in detail. Brackets **62** are fixed to the action brackets (not shown). The bracket **62** has a base portion **62***a* horizontal to the key bed **11**, a front wall portion **62***b* downwardly extending from the front end of the base portion **62***a*, a side wall portion **62***c* upwardly extending from a side of the base portion **62***a*, a guide portion **62***d* laterally projecting from the upper end of the side wall portion and a stopper portion **62***e* upwardly projecting from the rear end of the guide portion **62***d*. Both side portions of the rail base **66** extend over the guide portions **62***d*, and the rail base **66** is moved on or over the guide portions **82**. The stopper portions **62***e* do not allow the shank stopper **200** to be backwardly moved therebeyond. Thus, the stopper portions **62***e* form parts of the limiter **350***c*.

The transmitter **350***a* includes pins **203**/**213** upright on the base portions **62***a*, an arm member **202** rotatably supported by the pin **203**, an idler **212** also rotatably supported by the other pin **213** and pins **201**/**211** respectively fixed to the arm member/idler **202**/**212**. The pins **201**/**211** are rotatably connected to both end portions of the rail base **66**. The arm member **202** has a generally L-letter shape, and the pin **203** is received in a hole formed in the short portion of the arm member **202**. The torsion spring **201***a* is wound around the pin **203**, and is engaged with the long portion of the arm member **202**. The torsion spring **201***a* urges the arm member **202** in the clockwise direction at all times, and keeps the arm member **202** in contact with the transmitter **300** at the leading end **202***a* of the long portion thereof. Thus, the arm member **202** is not restrained to the transmitter **350***a*, but is only held in contact with the transmitter **350***a* due to the elastic force of the torsion spring **201***a*.

The pin **201** is spaced from the pin **203**, and is spaced from the pin **203** by a predetermined distance. The distance between the pin **203** and a contact surface **202***c* is maximized. The contact surface **202***c* is brought into contact with the side wall portion **62***c*, and sets a limit on the rotation of the shank stopper **200** in the counter clockwise direction. The idler **212** is shaped into an elliptical column, and the pin **211** is spaced from the pin **213** by the predetermined distance. The relative position between the pins **201** and **203** is same as the relative position between the pins **211** and **213**. The distance between the pin **211** and a contact surface **212***c* is maximized. The contact surface **212***c* is brought into contact with the side wall portion **62***c*, and sets the limit on the rotation of the shank stopper **200** in the counter clockwise direction together with the contact surface **202***c*. Thus, the contact surfaces **202***c*/**212***c* and the side wall portions **62***c* set a limit on the motion of the shank stopper **200**, and form parts of the limiter **350***c*. The virtual lines between the pins **201**/**211** and the pins **203**/**213**, the virtual line between the pins **201** and **211** and the virtual line between the pins **203** and **213** form a parallel link mechanism, which is rotatable around the pins **203**/**213**.

While the transmitter **350** does not exert any force on the arm member **202**, the torsion spring **201***a* urges the arm member **202** in the clockwise direction, and the arm member **202** and the idler **212** press the rail base **66** against the stopper portions **62***e* as shown in FIG. **4**A. The impact absorbers **68** are out of the trajectories of the hammer shanks **43**, and the shank stopper **200** is at the free position.

When the transmitter **350** exerts force on the arm member **202** in the direction toward the front, the arm member **202** and the idler **212** are driven for rotation in the counter clockwise direction against the elastic force of the torsion spring **201***a*. The arm member/idler **202**/**212** and, accordingly, the shank stopper **200** are rotated around the pins **203**/**213** as indicated by real lines in FIG. **4**B. The impact absorbers **68** are moved into the trajectories of the hammer shanks **43**, and the shank stopper **200** is changed to the blocking position. Thus, the arm member **202** and the idler **212** are rotated on virtual planes in parallel to the upper/lower surfaces of the rail base **66**. Although the force is transmitted to the arm member **202** on the left side of the shank stopper **200**, any twisting moment is not exerted on the shank stopper **200**, and the impact absorbers **68** are surely moved to the most appropriate blocking position without any twist.

The pin **201** is positioned on the left side of the pin **203** in the free position and on the right side of the pin **203** in the blocking position (see FIGS. **4**A and **4**B). Similarly, the pin **211** is positioned on the left side of the pin **213** in the free position and on the right side of the pin **213** in the blocking position. The relative position between the pins **201**/**211** and the pins **203**/**213** is desirable, because the rebound on the impact absorbers **68** does not result in unintentional change from the blocking position to the free position. In detail, when a pianist wants to change the shank stopper **200** from the blocking position to the free position, the pianist exerts moment on the arm member **202** so as to give rise to rotation of the arm member **202** in the clockwise direction around the pin **203**. However, when the hammer shank **43** rebounds on the impact absorber **68**, the impact generates the moment in the opposite direction, and the arm member **202** is driven for rotation in the counter clockwise direction around the pin **203**. The moment due to the impact is opposite in direction to the moment to be required for the change to the free position. Moreover, the contact surfaces **202***c*/**212***c* are held in contact with the side wall portions **62***c*, and set the limit on the rotation of the shank stopper **200** in the counter clockwise direction. Thus, the shank stopper **200** is never unintentionally changed to the free position. The impact force is transferred from the shank stopper **200** through the contact between the contact surfaces **202***c*/**212***c* and the side wall portions **62***c* to the brackets **62**, and the shank stopper **200** never vibrates.

The other transmitter **350***b* is illustrated in FIGS. **5**, **6**, **7** and **8** in detail. The other transmitter **350***b* is supported by a side board **304** by means of bolts **301**, and the muffler pedal **402** is connected through the transmitter **350***b* (see FIG. **8**) to the transmitter **350***a*. In this instance, the muffler pedal **402** is located between a soft pedal **401** and a damper pedal **403**. The soft pedal **401** and the damper pedal **403** are respectively connected to a soft pedal mechanism **404** and a damper pedal mechanism **406**. The soft pedal mechanism **404** and the damper pedal mechanism **406** are well known to skilled person, and no further description is incorporated therein. The side board **304** forms another part of the piano case.

The transmitter **350***b* includes a sliding box **303**, a shaft **305** and a base plate **306**. The base plate **306** is fixed to the side board **304** by means of the bolts **301**, and has a pair of bearing portions **306***a*. The bearing portions **306***a* are spaced from each other in the fore-and-aft direction, and the shaft **305** is supported at both ends thereof by the bearing portions **306***a*. The sliding box **303** has through-holes, and the shaft **305** passes the through-holes. The sliding box **303** is slidable along the shaft **305** in the fore-and-aft direction.

The transmitter **350***b* further includes a supporting block **301** and a pusher **300**. Plates **302***a*/**302***b* form in combination the supporting block **301**. The plate **302***a* has a projection **302***c* downwardly projecting from the lower end surface of the plate **302***a*, and is fixed to the sliding box **303** by means of bolts **301**. The plate **302***a* has an L-letter shape, and is fixed to the plate **302***b*. The plate **302***b* projects from the sliding box **303**, and is inwardly bent. The pusher **300** is formed with holes **300***a*, and the holes **300***a* are laterally elongated. The pusher **300** is connected through the holes **300***a* to the plate **302***a* by means of bolts **301**, and projects toward the hammer shank stopper **200**. The elongated holes **300***a* are desirable, because an assembly worker regulates the pusher **300** to appropriate position with respect to the arm member **202**. Thus, the pusher **300** is connected through the supporting block **301** to the sliding box **303**, and, accordingly, is movable in the fore-and-aft direction. When the sliding box **303** is frontwardly moved along the shaft **305**, the pusher **300** gives rise to the rotation of the arm member **202** against the elastic force of the torsion spring **201***a*, and the hammer shank **200** is changed to the blocking position.

The transmitter **350***b* further includes an arm member **308** swingably supported by the base plate **306** by means of a pin **309**, a connecting rod **307** connected between the projection **302***c* and the lower portion of the arm member **308** and a spring stretched between the connecting rod **307** and an anchor **311**. The connecting rod **307** has end portions **307***a*/**307***b* bent toward the side board **304**, and the end portions **307***a*/**307***b* are rotatably connected to the projection **302***a* and the arm member **308**, respectively. The anchor **311** is fixed to the side board **304**, and the spring **310** rearwardly urges the supporting block **302** and, accordingly, the sliding box **303** at all times. The elastic force is transmitted through the lower portion of the arm member **308**, and the moment urges the arm member **308** in the counter clockwise direction at all times. As a result, while any force is not exerted on the arm member **308**, the pusher **300** is spaced from the bearing portion **306***a* due to the elastic force of the spring **310**, and the torsion spring **201***a* keeps the arm member **202** held in contact with the pusher **300**.

The transmitter **350***b* further includes muffler links **400**/**410**/**412** and link levers **411**/**413**. A notch **308***a* is formed in the arm member **308**, and is rearwardly spaced from the pin **309**. The muffler link **400** is engaged with the arm member **308** at the notch **308***a*. When the muffler link **400** is pulled down, the counter moment is exerted on the arm member **308**, and gives rise to rotation in the clockwise direction against the moment due to the elastic force (see FIG. **7**). While the muffler link **400** is not pulled down, the muffler link **400** restricts the arm member **308**, and determines the position of the arm member **308** and, accordingly, the position of the pusher **300** (see FIG. **5**).

The link levers **411**/**413** are swingably supported by the piano case at intermediate portions thereof. The link lever **413** is located under the base plate **306**, and the other link lever **411** is laterally spaced from the link lever **413**. The link lever **413** is rotatably connected at one end thereof to the lower end portion of the muffler link **400** and at the other end thereof to one end portion of the muffler link **412**. The muffler link **412** laterally extends, and the other link lever **411** is rotatably connected at one end thereof to the other end of the muffler link **412** and at the other end thereof to one end of the muffler link **410**. The muffler link **410** vertically extends from the other end of the link lever **411** to the muffler pedal **402**. Though not shown in the drawings, a ratchet wheel is connected to the muffler pedal **402**, and a pawl is provided in association with the ratchet wheel. The pawl is engaged with the ratchet wheel, and the pawl and the ratchet wheel keep the muffler pedal **402** depressed. When the pawl is released from the ratchet wheel, a return spring (not shown) allows the muffler pedal **402** to return to the rest position.

A pianist changes the shank stopper **200** between the free position and the blocking position as follows. While the pianist keeps the muffler pedal **402** at the rest position, the muffler link **400** does not exert any force on the arm member **308**, and permits the spring **310** to incline the arm member **308** as shown in FIG. **5**. The spring **310** keeps the sliding box **303** and, accordingly, the pusher **300** at the rear end positions, and the torsion spring **201***a* keeps the arm member **202** held in contact with the pusher **300**. As a result, the arm member **202** keeps the rail base **66** retracted as shown in FIG. **4**A, and the impact absorbers **68** are out of the trajectories of the hammer shanks **43**.

The pianist is assumed to step on the muffler pedal **402**, the muffler link **410** is pulled down as indicated by arrow **AR400** (see FIG. **8**), and gives rise to rotation of the link lever **411** in the counter clockwise direction as indicated by arrow **AR401**. The link lever **411** rightwardly pulls the muffler link **412** as indicated by arrow **AR402**, and gives rise to rotation of the link lever **413** in the counter clockwise direction as indicated by arrow **AR403**. The link lever **413** pulls down the muffler link **400** as indicated by arrow **AR404**, and gives rise to the rotation of the arm member **308**.

The arm member **308** is driven for rotation in the clockwise direction as indicated by arrow **AR405** (see FIG. **7**), and frontwardly pulls the connecting rod **307** against the elastic force of the spring **310**. As a result, the sliding box **303** and, accordingly, the pusher **300** are frontwardly moved along the shaft **305** (compare FIG. **5** with FIG. **7**). The pusher **300** gives rise to the rotation of the arm member **202** around the pin **203** in the counter clockwise direction against the elastic force of the torsion spring **201***a*, and the rail base **66** is also rotated around the pins **203**/**213** in the counter clockwise direction (see FIG. **4**B). This results in that the impact absorbers **68** are moved into the trajectories of the hammer shanks **43**. Thus, the shank stopper **200** enters the blocking position. Even if the pianist leaves his foot from the muffler pedal **402**, the ratchet wheel and the pawl keep the muffler pedal **402** depressed, and the change-over mechanism **350** maintains the shank stopper **200** in the blocking position.

When the pianist releases the pawl from the ratchet wheel, the return spring (not shown) permits the muffler pedal **402** to return to the rest position, and the muffler links **410**/**412**/**400** and the link levers **411**/**413** are moved in the opposite directions to the directions indicated by arrows **AR400**/**AR402**/**AR404** and **AR401**/**AR403**. The counter moment is removed from the arm member **308**, and the spring **310** causes the connecting rod **307** to pull the lower portion of the arm member **308** and push the supporting block **302** and, accordingly, the sliding box **303** rearwardly. The sliding box **303** rearwardly slides along the shaft **305**, and positions the pusher to the rear end position as shown in FIG. **5**. While the pusher **300** is being moved toward the rear end position, the torsion spring **201***a* continuously urging the arm member **202** to keep it held in contact with the pusher **300**. The arm member **202** is driven for rotation around the pin **203** in the clockwise direction, and returns to the position shown in FIG. 4A. The rail base **66** is also rotated around the pins **203**/**213**, and retracts the impact absorbers **68** from the trajectories of the hammer shanks **43**. Thus, the change-over mechanism **350** changes the shank stopper **200** to the free position.

Turning back to FIG. **1**, the electronic sound generating system **3** comprises key sensors **3***a*, a controller **3***b* and a sound system such as, for example, a headphone **3***c*. The key sensors **3***a* are provided on the key bed **11**, and are respectively associated with the black/white keys **10**. The key sensor **3***a* is implemented by the combination of a shutter plate **3***d* and photo-couplers **3***e*. The shutter plate **3***d* is attached to the lower surface of the associated black/white key **10**, and the associated photo-couplers **3***e* are arranged along the trajectory of the shutter plate **3***d*.

A pianist is assumed to depress a black/white key **10**. The black/white key **10** is moved from the rest position toward the end position, and sinks the shutter plate **3***d*. The shutter plate **3***d* sequentially intersects the optical beams of the associated photo-couplers **3***e*, and the photo-couplers changes the bit pattern of a key position signal. When the pianist releases the depressed black/white key **10**, the black/white key **10** returns toward the rest position, and the shutter plate **3***d* is sequentially evacuated from the optical paths of the photo-couplers **3***e*. The key position signal changes the bit pattern, again. Thus, the key position signal is representative of the current key position of the associated black/white key **10**, and the key sensor **3***a* supplies the key position signal to the controller **3***b*.

The controller **3***b* includes a data processor and a tone generator. The data processor analyzes pieces of positional data representative of the variation of the bit pattern to see what key motion the pianist gives rise to. If the pianist gives rise to the downward key motion, the data processor instructs the tone generator to timely supply an audio signal to the headphone **3***c*, and the head-phone **3***c* generates the electronic sound corresponding to the acoustic sound to be produced by the associated hammer assembly **40**. On the other hand, if the pianist gives rise to the upward key motion, the data processor instructs the tone generator to decay the audio signal at the timing when the damper felt **54***c* is brought into contact with the set of strings S. Accordingly, the electronic sound is decayed. Thus, the electronic sound generating system **3** generates the electronic sounds corresponding to the acoustic tones along a passage.

The keyboard musical instrument behaves as follows. A pianist is assumed to play a tune in an acoustic sound mode. The pianist keeps the muffler pedal **402** at the rest position, and the change-over mechanism **350** maintains the shank stopper **200** in the free position. While the pianist is playing the tone on the keyboard **4**, the depressed black/white keys **10** sequentially actuate the associated action mechanisms **5**, and the jacks **26** escapes from the hammer butts **41**. The jacks **26** give rise to the free rotations of the associated hammer assemblies **40**, and the hammer heads **44** sequentially strike the associated sets of strings S. The strings S vibrate for generating the acoustic tones. Thus, the acoustic piano **1** sequentially generates the acoustic tones along the tune. The shank stopper **200** at the free position does not interrupt the hammer actions.

The pianist is assumed to play a tune in a silent mode. The pianist steps on the muffler pedal **402**, and the pawl and the ratchet wheel keep the muffler pedal **402** depressed. The muffler pedal **402** actuates the change-over mechanism **350** so as to change the shank stopper **200** to the blocking position. The impact absorbers **68** are moved into the trajectories of the hammer shanks **43**. While the pianist is playing the tune on the keyboard **4**, the depressed black/white keys **10** sequentially actuate the action mechanisms **5**, and the jacks **26** escape the hammer butts **41**. Although the jacks **26** give rise to the free rotations of the hammer assemblies **40**, the hammer shanks **43** rebound on the impact absorbers **68** before the hammer heads **44** reach the strings S as shown in FIG. **9**. Any acoustic tone is not generated from the strings S.

The key sensors **3***a* are respectively monitoring the associated black/white keys **10** during the fingering on the keyboard **4**, and periodically report the current key positions of the black/white keys **10**. The data processor analyzes the pieces of positional data. The data processor determines the electronic sounds to be produced in response to the fingering, and instructs the tone generator to generate the audio signal for the electronic sounds. The data processor further determines the electronic sounds to be decayed in response to the fingering, and instructs the tone generator to decay the electronic sounds. Thus, the electronic sound generating system **3** is responsive to the fingering on the keyboard, and sequentially generates the electronic sounds along the tune.

When user requests the manufacturer to add the silent system **2** and the electronic sound generating system **3** to the upright piano **1**, the manufacturer sends workmen to user's home. The workmen attach the brackets **62** to the action brackets, and assemble the transmitter **350***a* and the shank stopper **200** with the brackets **62**. The workmen regulate the relative position between the base rail **66** and the stopper rail segments **67***a*/**67***b*/**67***c* so as to adjust the shank stopper **200** to the optimum blocking position. The workmen fixes the base plate **306** and the anchor **311** to the side board **304**, and connect the muffler link **400** to the arm member **308**. The workmen regulate the position of the muffler link **400** with respect to the notch **308***a* so as to adjust the pusher **300** at the optimum rear position. The pusher **300** at the optimum rear position is held in contact with the arm member **202** at the free position. Thus, the transmitter **350***b* and the shank stopper **200** are independently regulated to the optimum positions. The workmen install the electronic sound generating system **3** inside the upright piano, and complete the retrofitting.

The manufacturer is assumed to replace a part of the transmitter **350***a*/**350***b* or a part of the shank stopper with new one. The manufacturer sends workmen to user's home, and the workmen disassemble the transmitter **350***a* or the transmitter **350***b* assembled with the shank stopper **200**. The transmitter **350***a* is only in contact with the transmitter **350***b*. For this reason, the transmitter/shank stopper **350***a*/**200** or the other transmitter **350***b* remains inside the acoustic piano **1**. The transmitter **350***a* or the other transmitter/hammer stopper **350***b*/**200** is repaired, and, thereafter, assembled with the transmitter **350***b* or **350***a*. The assembling work is easy because the transmitters **350***a* and **350***b* are connected through the contact between the arm member **202** and the pusher **300**. Moreover, the muffler pedal **402**, the muffler links **400**/**412**/**410** and the link levers **41**/**413** are available for the transmitter **350***b*, and only a few new parts are required for the retrofitting.

In this instance, the upright piano **1** serves as an acoustic keyboard. The force is transmitted from the pusher **300** to the arm member **202**, and the direction to transmit the force to the arm member **202** is corresponding to a second direction. The pusher **300** is not linked with the arm member

202 in a direction opposite to the force transmitting direction, and, accordingly, the opposite direction is corresponding to a first direction. The first direction may be any direction except the force transmitting direction. When the rail base **66** is brought into contact with the stopper portions **62***e*, the torsion spring **201***a* does not urge the arm member **202** to keep the contact with the pusher **300**. The position at which the rail base is brought into contact with the stopper portion **62***e* defines a boundary of a predetermined range.

Second Embodiment

FIG. **10** illustrates another keyboard musical instrument embodying the present invention. The keyboard musical instrument implementing the second embodiment largely comprises an acoustic piano, a silent system, an electronic sound generating system and an automatic playing system **500**. The acoustic piano, the silent system and the electronic sound generating system are similar to those of the first embodiment, and parts are labeled with the same references designating the corresponding parts of the first embodiment. Description is hereinbelow focused on the automatic playing system **500**.

The automatic playing system **500** includes solenoid-operated key actuators **501** and the controller **3***b*. The controller **3***b* is shared between the automatic playing system **500** and the electronic sound generating system **3**. However, computer programs for controlling the automatic playing system **500** are further stored in the program memory (not shown). The solenoid-operated key actuators **501** are placed on the key bed **11**, and are respectively associated with the black/white keys **10**. The solenoid-operated key actuators **501** are similar in structure to one another, and each solenoid-operated key actuator **501** has a solenoid **502**, a plunger **503** and a cushion **504**. The solenoid **502** is mounted on the key bed **11**, and is connected to a driver circuit (not shown) of the controller **3***b*. The plunger **503** is upwardly projectable from and downwardly retractable into the solenoid **502**, and the cushion **504** is attached to the leading end of the plunger **503**.

A set of music data codes is stored in a working memory (not shown) of the controller **3***b*, and the data processor sequentially reads out the music data codes from the working memory. The data processor checks the music data codes to see whether or not any solenoid-operated key actuator **501** is energized. If the music data code is representative of a key-on event, the data processor instructs the driver circuit to supply a driving signal to the solenoid. Then, the plunger **503** projects from the solenoid **502**, and pushes the associated black/white key **10**. On the other hand, if the music data code is representative of a key-off event, the data processor instructs the driver circuit to decay the driving signal, and the plunger **503** is retracted into the solenoid **502**. Thus, the array of solenoid-operated key actuators selectively moves the black/white keys **10** without any fingering, and plays a tune on the keyboard **4**.

The keyboard musical instrument implementing the second embodiment behaves as similar to the first embodiment in the acoustic sound mode and the silent mode, and no further description is incorporated hereinbelow.

As will be appreciated from the foregoing description, the change-over mechanism has the transmitters **350***a*/**350***b* held in contact with each other without any binding. The transmitters **350***a*/**350***b* are independently disassembled and regulated. This results in easy repairing work or easy retrofitting.

Although particular embodiments of the present invention have been shown and described, it will be apparent to those skilled in the art that various changes and modifications may be made without departing from the spirit and scope of the present invention.

The pedal **402** may be newly added to the acoustic piano **1**. In this instance, the acoustic piano may have the pedal **402**, the soft pedal **401**, the damper pedal **403** and a muffler pedal connected to a muffler frame.

The pusher **300** may be connected through a suitable transmission mechanism to a grip, which the pianist manipulates.

The pusher **300** may be directly or indirectly connected to a suitable actuator such as, for example, a solenoid-operated actuator. The sliding box **303** may be moved by means of a suitable actuator such as, for example, a ball tread unit connected to an electric motor.

The pusher **300** may bi-directionally push the arm member **202**. In this instance, the torsion spring **201***a* is deleted from the transmitter **350***a*.

The acoustic piano **1** may be a grand piano. The present invention is applicable to another kind of acoustic keyboard musical instrument such as, for example, a celesta. The celesta, the grand piano and the upright piano serve as an acoustic keyboard.

What is claimed is:

1. keyboard musical instrument comprising

an acoustic keyboard including plural keys respectively assigned pitch names and selectively depressed by a player, plural music strings respectively associated with said plural keys and plural strikers driven by depressing said plural keys for striking the associated music strings, and

a silent system including

a stopper moved between a free position and a blocking position so that said plural strikers strike said plural music strings without any interruption thereof at said free position and rebound thereon at said blocking position before striking said plural music strings and

a change-over mechanism having a first transmitter connected to said stopper for changing said stopper between said free position and said blocking position and a second transmitter held in contact with said first transmitter without any restriction in a first direction for transmitting a force to said first transmitter in a second direction different from said first direction.

2. The keyboard musical instrument as set forth in claim **1**, in which said first transmitter and said second transmitter have a first member and a second member held in contact with each other, respectively, and said change-over mechanism further has an elastic member urging one of said first and second members in a direction to keep said first and second members in contact with each other in so far as the other of said first and second members is in a predetermined range.

3. The keyboard musical instrument as set forth in claim **2**, in which said elastic member urges said stopper through said one of said first and second members toward said free position.

4. The keyboard musical instrument as set forth in claim **3**, in which said stopper urges said one of said first and second members in a direction opposite to the direction toward said free position when said strikers give impact to said stopper in said blocking position.

5. The keyboard musical instrument as set forth in claim **4**, in which said first transmitter further has

a first pin connected between a stationary member and said first member so as to allow said first member to be rotated therearound, a second pin provided between said first member and one end portion of said stopper so as to allow said first member and said stopper to turn with respect to each other,

a third member located around the other end portion of said stopper,

a third pin connected between another stationary member and said third member so as to allow said third member to be rotated therearound,

a fourth pin provided between said third member and said other end portion of said stopper so as to allow said third member and said stopper to turn with respect to each other, said first pin, said second pin, said third pin and said fourth pin being arranged in such a manner that four virtual lines therebetween form a parallel four link mechanism, and

said elastic member connected to said first member so as to urge said stopper to turn around said first and third pins in said direction toward said free position.

6. The keyboard musical instrument as set forth in claim **1**, in which said acoustic keyboard is a piano.

7. The keyboard musical instrument as set forth in claim **6**, in which said acoustic keyboard further includes plural action mechanisms respectively connected to said plural keys and selectively actuated by the associated keys so as to drive hammers respectively serving as said strikers for rotation toward said associated music strings.

8. The keyboard musical instrument as set forth in claim **6**, in which said second transmitter includes a pusher held in contact with said first transmitter and a transmission mechanism connected between said pusher and a pedal depressed by said player.

9. The keyboard musical instrument as set forth in claim **6**, in which said piano has a muffler pedal provided between

a soft pedal and a damper pedal, and said second transmitter includes muffler links connected in series to said muffler pedal, a pusher held in contact with said first transmitter and a transmission mechanism connected between one of said muffler links and said pusher.

10. The keyboard musical instrument as set forth in claim **8**, in which a relative position between said pusher and said transmission mechanism is regulable.

11. The keyboard musical instrument as set forth in claim **8**, in which said pusher is held in contact with a member of said first transmitter by means of an elastic member in so far as said member is in a predetermined range.

12. The keyboard musical instrument as set forth in claim **11**, in which said second direction is identical with a direction in which said pusher pushes said member for changing said stopper from said free position to said blocking position.

13. The keyboard musical instrument as set forth in claim **6**, further comprising an electronic sound generating system including

plural key sensors respectively associated with said plural keys and detecting current positions of said plural keys for producing key position signals representative of said current positions,

a controller connected to said plural key sensors and producing an audio signal representative of electronic sounds having the pitch names identical with those assigned to the depressed keys, and

a sound system connected to said controller and producing said electronic sounds from said audio signal.

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